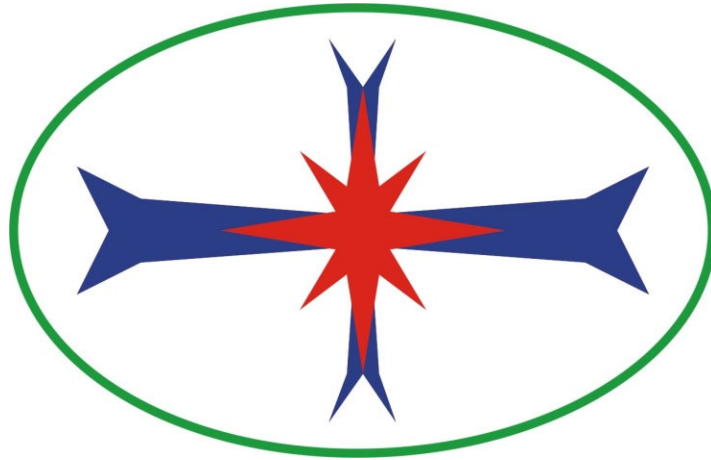
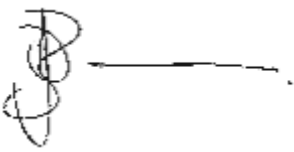


Blast Management & Consulting



Quality Service on Time

Report: Underground Blasting Impact an Appendix to Report: Blast Impact Assessment Waterberg JV Resources (Pty) Ltd Proposed Waterberg Project

Date:	03 April 2023
BM&C Ref No:	Platinum Group Metals_Waterberg Project_EIARReport_230403App1
Client Ref No:	n/a
Signed:	
Name:	JD Zeeman

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ii. Independence Declaration

Blast Management & Consulting is an independent company. The work done for the report was performed in an objective manner and according to national and international standards, which means that the results and findings may not all be positive for the client. Blast Management & Consulting has the required expertise to conduct such an investigation and draft the specialist report relevant to the study. Blast Management & Consulting did not engage in any behaviour that could be result in a conflict of interest in undertaking this study.

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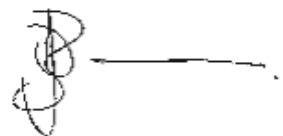
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List of Acronyms used in this Report

a and b	Site Constant
ANFO	Ammonium nitrate fuel oil
B	Burden (m)
BH	Blast Hole
BM&C	Blast Management & Consulting
Bs	Scaled Burden ($m^{3/2}kg^{-1/2}$)
D	Distance (m)
D	Duration (s)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
I&AP	Interested and Affected Parties
k	Factor value
Lat/Lon	Latitude/Longitude
hddd°mm'ss.s"	Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
P	Probability
POI	Points of Interest
PPV	Peak Particle Velocity
S	Scale
SH	Stemming height (m)
T	Blasted Tonnage
USBM	United States Bureau of Mine
WGS 84	Coordinates (South African)
WM	With Mitigation Measures
WOM	Without Mitigation Measures

List of Units used in this Report

%	percentage
cm	centimetre
g/cm ³	gram per cubic centimetre
Hz	frequency
kg	kilogram

kg/m ³	kilogram per cubic metre
kg/t	kilogram per tonne
km	kilometre
m	metre
m ²	metre squared
mm/s	millimetres per second
mm/s ²	millimetres per second square
ms	milliseconds

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1 Executive Summary

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform a review of possible impacts from underground blasting operations on the farms Bonne Esperance 356 LR and Too Late 359 LR with regards to ground vibration.

The evaluation of ground vibration expected from underground blasting operations indicated that levels expected are very low and insignificant. The distance between blasting operations and surface area are in the order of 1200 m. This distance and the low quantities of charge are the main contributors to the insignificant levels of ground vibration. No impact on surface is expected.

Due to the low levels expected there is no specific mitigations required.

This concludes this investigation for the possible impact of underground blasting operations on the farms Bonne Esperance 356 LR and Too Late 359 LR for the proposed Waterberg Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

2 Introduction

The Waterberg Project is located approximately 80km northwest of Polokwane and approximately 25km southwest of Bochum in the southern portion of the Blouberg Local Municipality of the Capricorn District Municipality, Limpopo province of the Republic of South Africa at coordinates (Lat/Lon WGS84) 23°22'41.81"S; 28°53'35.62"E and will comprise the following Farms:

- Rosamond 357 LR.
- Millstream 358 LR.
- Disseldorp 369 LR.
- Ketting 368 LR.
- Lomondside 323 LR.
- Early Dawn 361 LR.
- Old Langsine 360 LR.
- Langbryde 324 LR.
- Goedetrouw 366 LR; and
- Portion 1 of Goedetrouw 366 LR
- Portion 1 of Norma 365 LR
- Remaining Extent of Norma 365 LR; and
- Portions 10, 12, 13 and 14 of the Farm Harriet's Wish"

The mineral resources targeted are mineable platinum group metals, mainly palladium. The resources are in a newly discovered part of the Bushveld Complex under cover rocks. Two new layers for platinum group metals were discovered in 2011 and 2012 by the company's founders. The "T and F reefs" at Waterberg are distinct from the known Merensky, UG-2 and Platreef zones, known previously. The deposit is 3m up to 100m thick and dips at 35-40 degrees. This configuration requires mechanised mining skills and equipment maintenance skills.

This project is a greenfields project with no existing blasting operations.

Additional underground ground areas for the farms Bonne Esperance 356 LR and Too Late 359 LR to be considered in this report. Only underground operations are to be done on these farm areas targeting the Bushveld F Zone 1200 – 1500 m with the mining target from 1400 – 1500 m below surface.

As part of the Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations and specifically for the proposed Waterberg Mine Project extended area. Ground vibration from blasting operations is the only possible influence that blasting may have on the surface area in this respect. The report

concentrates on ground vibration and intends to provide information, calculations, predictions, possible influences and mitigating aspects of blasting operations for the project.

3 Objectives

The objective of this document is defining the possible impact from the underground blasting operations for the farms Bonne Esperance 356 LR and Too Late 359 LR outlining the expected environmental effects that blasting operations could have on the surface area environment and proposing the specific mitigation measures that will be required.

The objectives were dealt with whilst taking specific protocols into consideration. The protocols applied in this document are based on the author's experience, guidelines taken from literature research, client requirements and general indicators in the various appropriate pieces of South African legislation. There is no direct reference in the following acts to requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- National Environmental Management Act No. 107 of 1998.
- Mine Health and Safety Act No. 29 of 1996.
- Mineral and Petroleum Resources Development Act No. 28 of 2002.
- Explosives Act No. 15 of 2003.

The guidelines and safe blasting criteria are based on internationally accepted standards and specifically criteria for safe blasting for ground vibration and recommendations on air blast published by the United States Bureau of Mines (USBM). There are no specific South African standards and the USBM is well accepted as standard for South Africa.

4 Scope of blast impact study

The scope of the study is determined by the terms of reference to achieve the objectives. The terms of reference can be summarised according to the following steps taken as part of the EIA study with regard to ground vibration, air blast and fly rock due to blasting operations.

- Background information of the proposed site.
- Blasting Operation Requirements.
- Site specific evaluation of blasting operations according to the following:
 - Evaluation of expected ground vibration levels from blasting operations on surface.
 - Evaluation of expected ground vibration influence on the sensitive nature of the Makgabeng Plateau.

- Impact Assessment.
- Mitigations.
- Recommendations.
- Conclusion.

5 Study area

The Waterberg Project is located approximately 80km northwest of Polokwane and approximately 25km southwest of Bochum in the southern portion of the Blouberg Local Municipality of the Capricorn District Municipality, Limpopo province of the Republic of South Africa at coordinates (Lat/Lon WGS84) 23°22'41.81"S; 28°53'35.62"E.

Figure 1 shows a Locality Map of the area for the farms Bonne Esperance 356 LR and Too Late 359 LR proposed Project area.

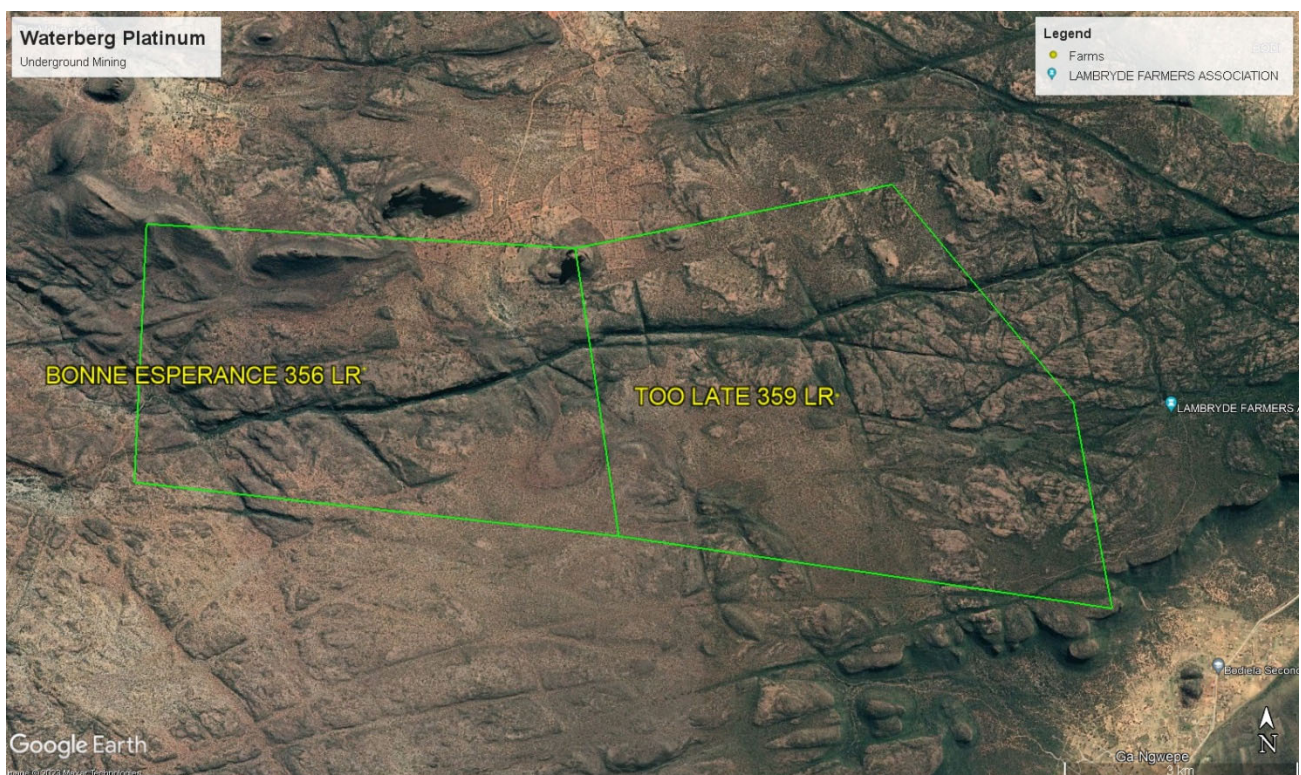


Figure 1: Farms areas of the proposed underground area

6 Methodology

The detailed plan of study consists of the following sections:

- Identifying surface infrastructure and sensitive areas that are found within reason of the project site. A list of Point of Interests (POI's) is created that will be used for evaluation.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is calculation of the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration. These values are then calculated over the distance investigated from site and shown as amplitude levels.
- Reporting: All data is prepared in a single report and provided for review.

7 Site Investigation

The site was visited on 11 March 2019 for the initial evaluation. An additional site visit was not considered.

8 Season applicable to the investigation

The underground drilling and blasting operations are not season dependent.

9 Assumptions and Limitations

The following assumptions have been made:

- The project is evaluated as a new operation with no blasting activities currently being done.
- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- Detail mine plan was not available for the areas investigated. Expected targeted ore depths below surface was provided and used.
- Expected designs to be used for development of underground access and production was provided. Information from these designs was used to determined expected levels of ground vibration and possible impacts.
- The work done is based on the author's knowledge and information provided by the project applicant.

10 Sensitivity of Project

Areas of sensitive nature was identified and requires specific mention.

Specific mention is made of the Makgabeng Plateau located on the farm Too Late 359 LR. Figure 2 shows the area indicated as POI02.



Figure 2: Identified sensitive area

11 Consultation process

No specific consultation with external parties was utilised. The work done is based on the author's knowledge and information provided by the client.

12 Influence from blasting operations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of blasting process. Based on the regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated, there are no specific South African ground vibration and air blast limit standards.

12.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick-and-mortar house will be more resistant to vibrations than a poorly constructed or a traditionally built mud house. Different limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages.

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 3 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

- Analysed data displayed in the bottom half of the graph shows safe ground vibration levels,
- Analysed data displayed in the top half of the graph shows potentially unsafe ground vibration levels:

Added to the USBM graph is a blue line and green dotted line that represents 6 mm/s and 12.5 mm/s additional criteria that are used by BM&C.

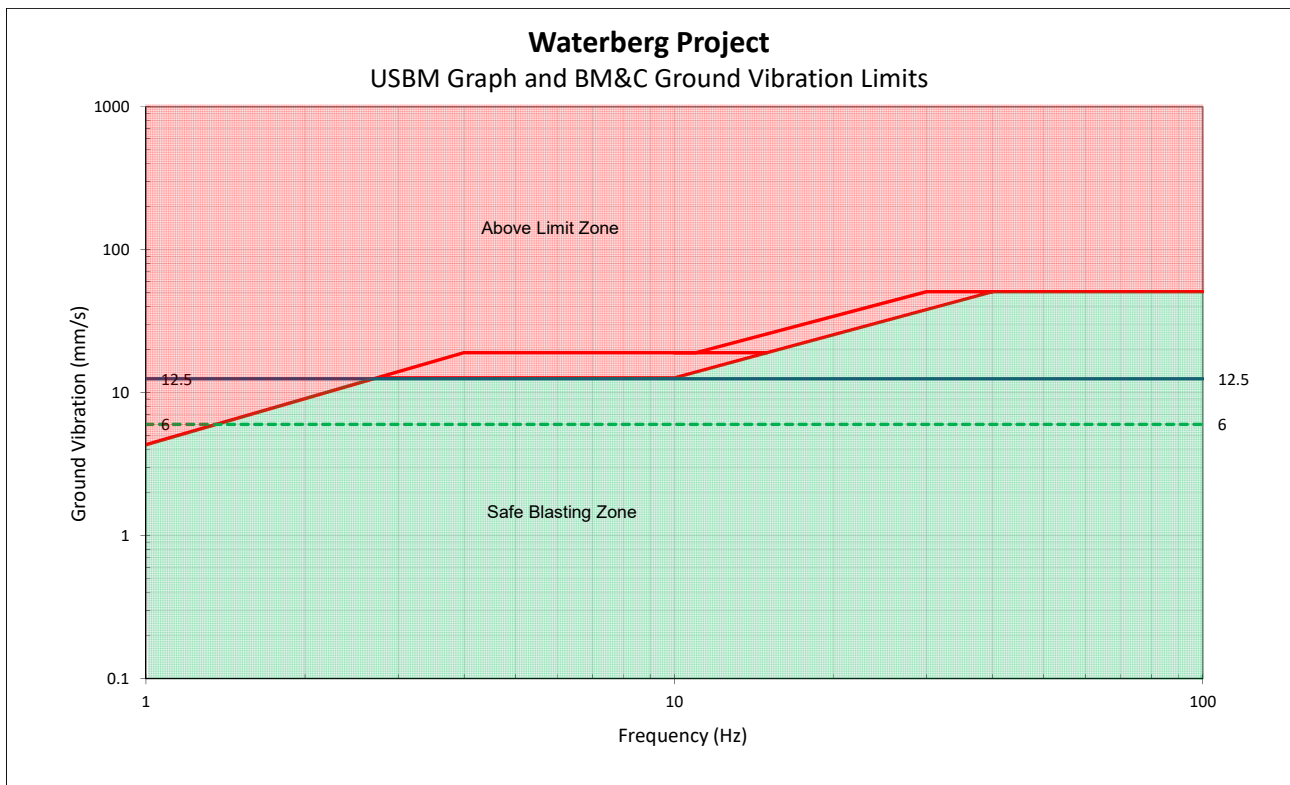


Figure 3: USBM Analysis Graph

Additional limitations that should be considered were determined through research and prescribed by the various institutions; these are as follows:

- National roads/tar roads: 150 mm/s BM&C.
- Steel pipelines: 50 mm/s (Rand Water Board).
- Electrical lines: 75 mm/s (Eskom).
- Sasol Pipelines: 25 mms/s (Sasol).
- Railways: 150 mm/s BM&C.
- Concrete less than 3 days old: 5 mm/s ¹;
- Concrete after 10 days: 200 mm/s ²;

¹ Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

² Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

- Sensitive plant equipment: 12 mm/s or 25 mm/s, depending on type. (Some switches could trip at levels of less than 25 mm/s.)².
- Waterwells or Boreholes: 50 mm/s³;

Considering the above limitations, BM&C work is based on the following:

- USBM criteria for safe blasting.
- The additional limits provided above.
- Consideration of private structures in the area of influence.
- Should structures be in poor condition, the basic limit of 25 mm/s is halved to 12.5 mm/s or when structures are in very poor condition limits will be restricted to 6 mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures.
- Traditionally built mud houses are limited to 6 mm/s. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise.
- Input from other consultants in the field locally and internationally.

12.2 Ground vibration and human perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perceptions. It should be realized that the legal limit set for structures is significantly greater than the comfort zone of human beings. Humans and animals are sensitive to ground vibration and the vibration of structures. Research has shown that humans will respond to different levels of ground vibration at different frequencies.

Ground vibration is experienced at different levels; BM&C considers only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable”. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 4.5 mm/s as unpleasant (See Figure 4). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

Indicated on Figure 4 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation.

³ Berger P. R., & Associates Inc., Bradfordwoods, Pennsylvania, 15015, Nov 1980, Survey of Blasting Effects on Ground Water Supplies in Appalachia., Prepared for United States Department of Interior Bureau of Mines.

Generally, people also assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints.

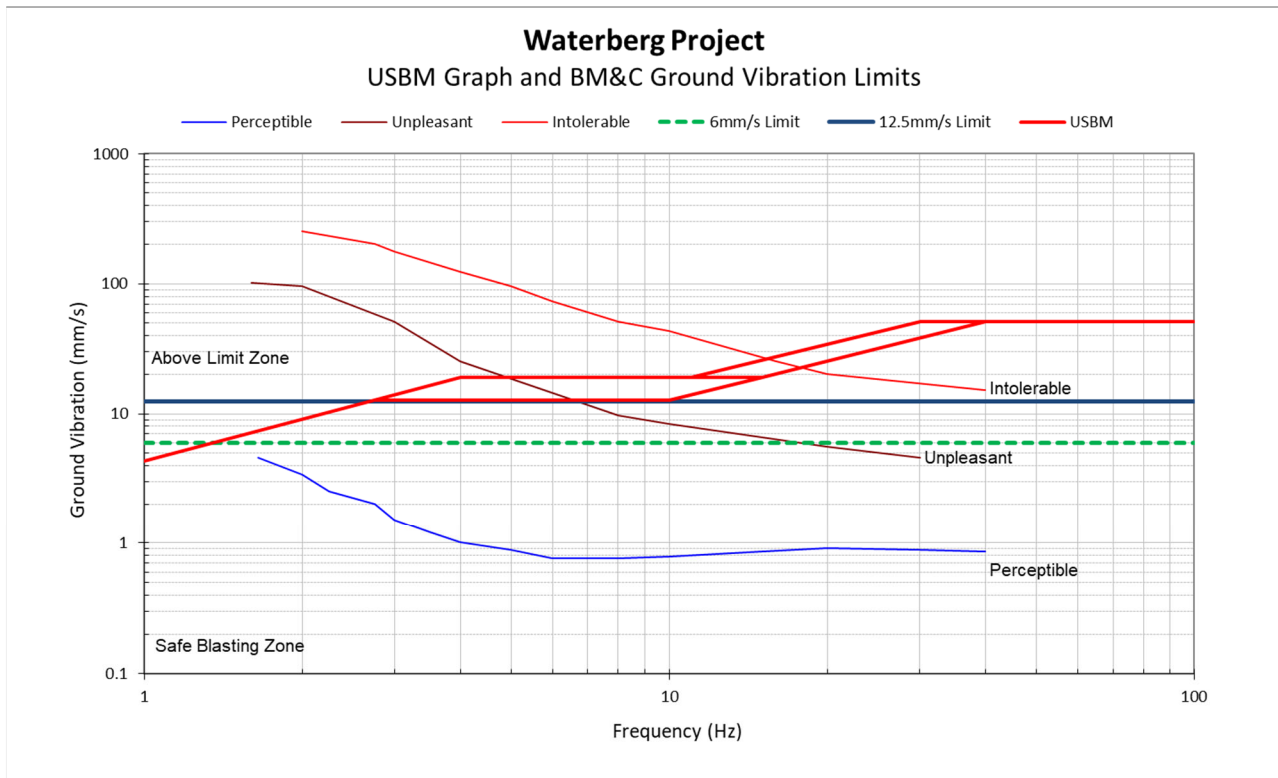


Figure 4: USBM Analysis with Human Perception

12.3 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.

Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is “Promote good neighbour ship”. This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it,

could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general, it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,
- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

12.4 Cracking of houses and consequent devaluation

Houses in general have cracks. It is reported that a house could develop up to 15 cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur and a result is shown in Figure 5 below. A typical X crack formation is observed.

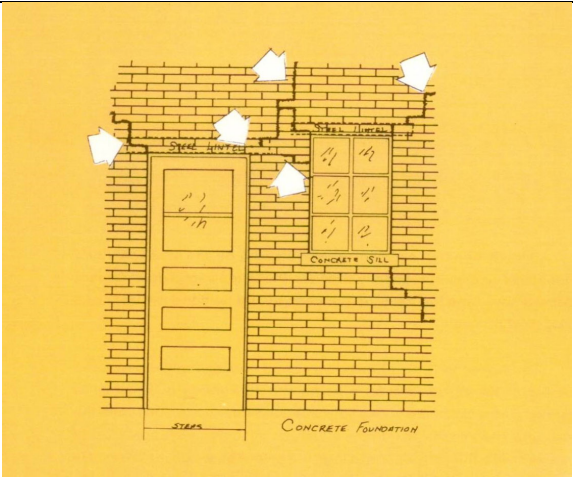
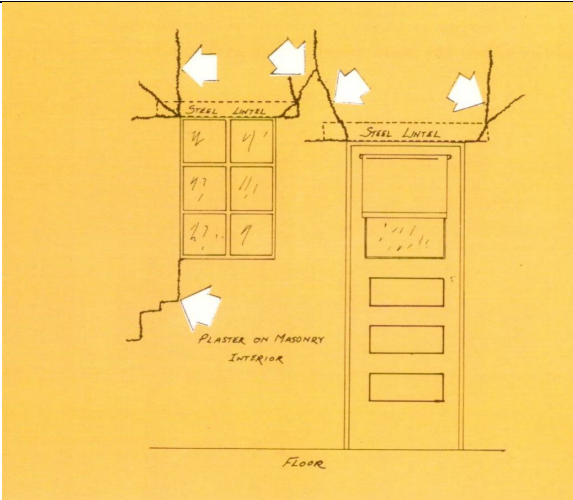
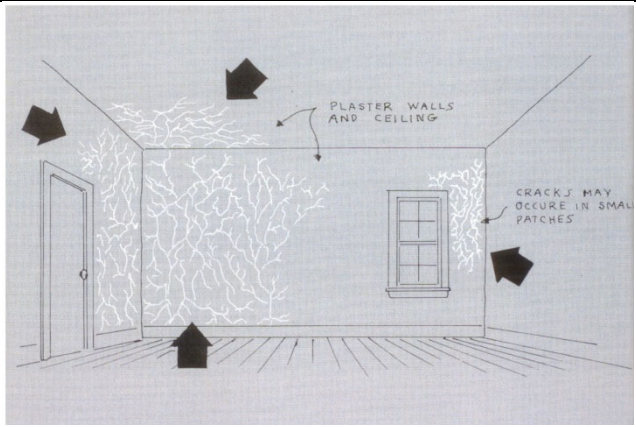
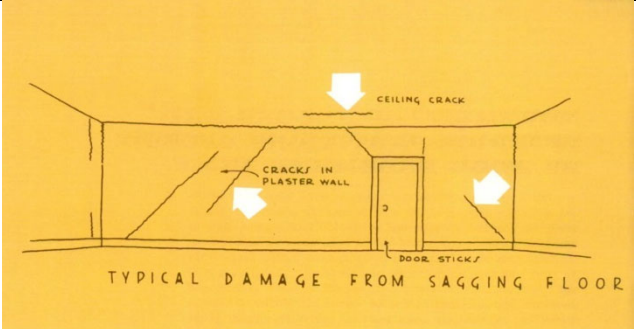


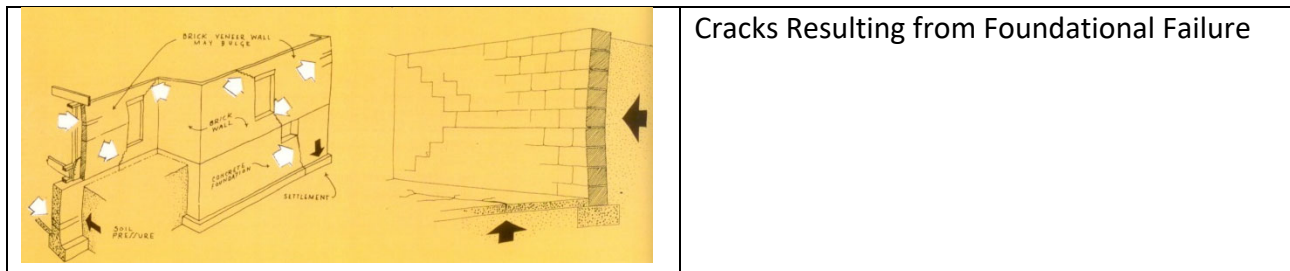
Figure 5: Example of blast induced damage.

The table below with figures show illustrations of non-blasting damage that could be found.

Table 1: Examples of typical non-blasting cracks

	<p>Cracks Resulting from Shrinkage of Concrete Blocks</p>
--	---

	<p>Typical Lintel Cracks</p>
	<p>Typical Lintel Cracks</p>
	<p>“Cracking” Cracks on Plaster</p>
	<p>Plaster Cracks Caused by Sagging Floors</p>



Cracks Resulting from Foundational Failure

Observing cracks in the form indicated in Figure 5 on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied and the general existence of cracks may be due to materials used. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

13 Baseline Results

The base line information for the project is limited to observation of the surrounding environment only. There is no drilling and blasting activities conducted that could contribute to measurements for a baseline.

13.1 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed and detailed here. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present on surface of the two farm areas. A list was prepared of all structures in the vicinity of the box-cut area. – see Table 3 below. Figure 6 shows an aerial view of the farms with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as “Classification” in Table 2. The classification used is a BMC classification and does not relate to any standard or national or international code or practice. Table 2 shows the descriptions for the classifications used.

Table 2: POI Classification used

Class	Description
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas

3	Office and High-rise buildings
4	Animal related installations and animal sensitive areas
5	Industrial buildings and installations
6	Earth like structures – no surface structure
7	Heritage
8	Water Borehole

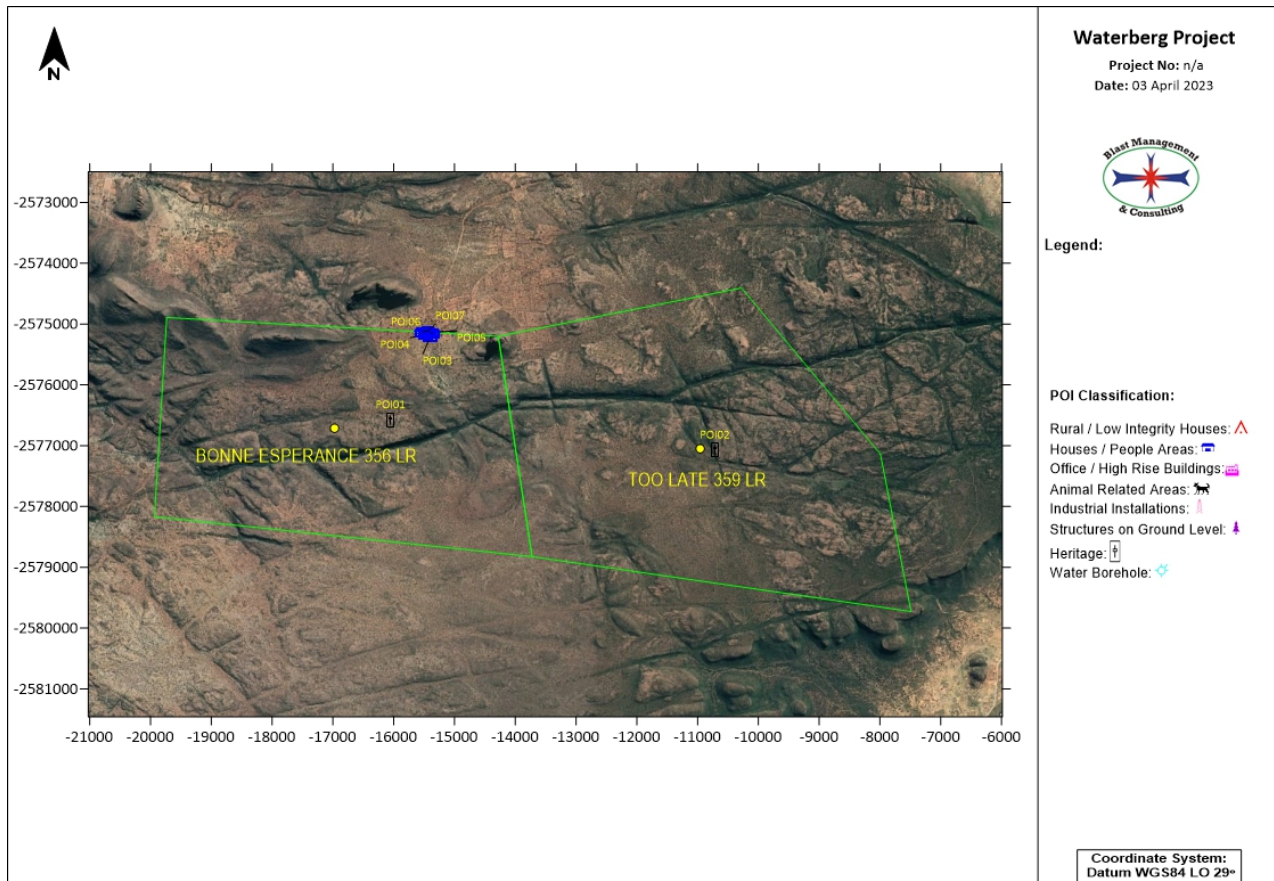


Figure 6: Aerial view of farm areas with points of interest identified

Table 3: List of points of interest identified (WGS – LO 29°)

Tag	Description	Classification	Y	X
POI01	The Arch - View Point	7	16045.51	2576579.165
POI02	Makgabeng Plateau	7	10711.85	2577073.783
POI03	House	2	15402.711	2575215.639
POI04	House	2	15475.301	2575178.41
POI05	House	2	15522.672	2575138.116
POI06	House	2	15354.445	2575152.007
POI07	House	2	15443.344	2575119.257

14 Blasting Operations

The mineral resources targeted are mineable platinum group metals, mainly palladium. The resources are in a newly discovered part of the Bushveld Complex under cover rocks. Two new layers for platinum group metals were discovered in 2011 and 2012 by the company's founders. The "T and F reefs" at Waterberg are distinct from the Merensky, UG-2 and Platreef zones, known previously. The deposit is 3m up to 100m thick and dips at 35-40 degrees. This configuration requires mechanised mining skills and equipment maintenance skills.

The mining method is more fully summarised in the Mining Work Programme ("MWP"), also filed as part of the Mining Right Application. As a result of the orebody thickness, mining is planned to be fully mechanised. During the Pre-feasibility Study ("PFS"), three mining methods were applied, namely, (1) Blind Long Hole Retreat ("BLR"); (2) Longitudinal (Strike) Long Hole Open Stopping ("SLOS"); and (3) Transverse Long Hole Open Stopping ("TLOS").

All three of the above-mentioned methods are being considered as part of the on-going Definitive Feasibility Study ("DFS"). All the methods are fully mechanised and involve large scale underground mining equipment. The mining method has a significant advantage in safety since most of the ore moving work will be done by machine, with employees located inside a cab while operating a mobile piece of equipment. Additionally, the proposed mining methods are advantageous in terms of cost and efficiency.

Exact final blast designs that will be applied on this section of the underground operation are not yet presented due that the mining in these areas is only scheduled much later. Currently blast designs considered that may be applied development ends and production mining are estimates. The information from these designs is considered for the evaluation of the ground vibration impact.

The following design information is presented for the development ends and the production operations.

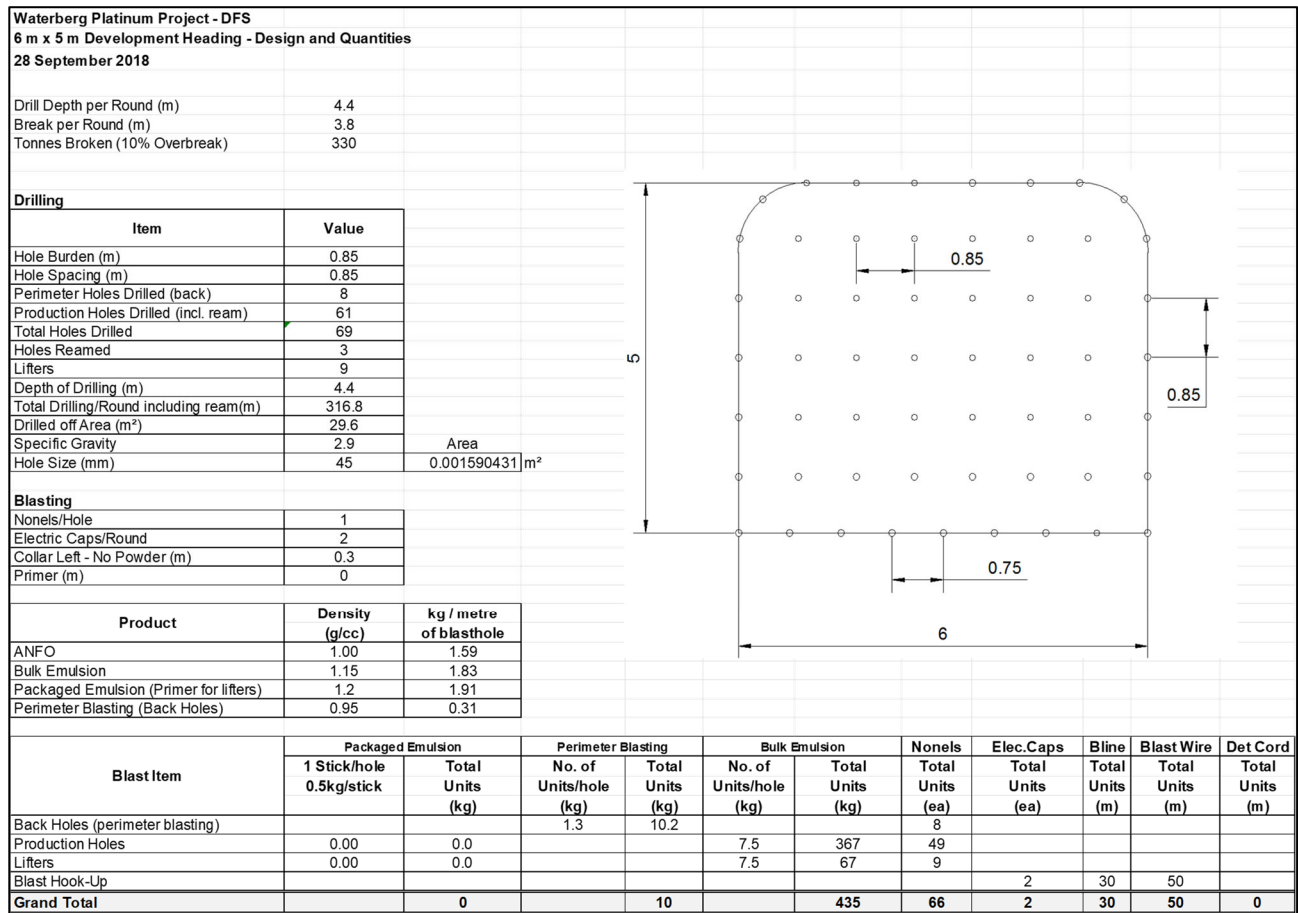


Figure 7: Development end Design

Table 28: Transverse Slope Production Drilling Parameters

Item	Transverse 40 m High 24 m Thick	Transverse 20 m High 24 m Thick	Transverse 40 m High 48 m Thick	Transverse 20 m High 48 m Thick
Hole Diameter	76.0 mm	76.0 mm	76.0 mm	76.0 mm
Ring Spacing	2.2 m	2.2 m	2.2 m	2.2 m
Hole Burden	2.5 m	2.5 m	2.5 m	2.5 m
Total Drilling	8 456.0 m	3 972.0 m	18 156.0 m	8 708.0 m
Slope Tonnes	67 000.0 t	32 200.0 t	149 200.0 t	71 700.0 t
Drill Factor	7.9 tpm	8.1 tpm	8.2 tpm	8.2 tpm
Average Hole Length	17.0 m	14.0 m	17.0 m	14.0 m

Table 29: Longitudinal Slope Production Drilling Parameters

Item	Longitudinal 40 m High 8 m Thick	Longitudinal 20 m High 8 m Thick	Longitudinal 40 m High 3 m Thick	Longitudinal 20 m High 3 m Thick
Hole Diameter	76 mm	76 mm	76 mm	76mm
Ring Spacing	2.2 m	2.2 m	2.2 m	2.2 m
Hole Burden	2.5 m	2.5 m	2.5 m	2.5 m
Total Drilling	2 867 m	1 313 m	1 670 m	725 m
Slope Tonnes	26 600 t	12 400 t	11 400 t	5 100 t
Drill Factor	9.3 tpm	9.4 tpm	6.8 tpm	7.0 tpm
Average Hole Length	17 m	13 m	27 m	23 m

3.6.3 Longhole Blasting

Bulk emulsion will be used for production blasting. A mobile emulsion loading unit will be used to load the holes. The production blasting design basis is summarised in Table 30.

Table 30: Longhole Blasting Parameters

Item	Parameter
Explosives Type	Bulk Emulsion (Density 1 150 kg/m ³)
Detonator	Non-electric Detonator
Initiation	Electric Cap and Detonator Cord Mine wide Central Blast System

Figure 8: Production Design

The estimated powder factor for each typical slope size is summarised in Table 31 and Table 32.

Table 31: Transverse Longhole Powder Factor

Item	Transverse 40 m High 21 m Thick	Transverse 20 m High 21 m Thick	Transverse 40 m High 48 m Thick	Transverse 20 m High 48 m Thick
Hole Diameter	76 mm	76 mm	76 mm	76 mm
Total Drilling	8 456 m	3 972 m	18 156 m	8 708 m
Loaded Length	5 083 m	2 390 m	10 920 m	5 244 m
Total Emulsion	27 846 kg	13 092 kg	59 816 kg	27 358 kg
Slope Tonnes	67 000 t	32 200 t	149 200 t	71 700 t
Powder Factor	0.42 kg/t	0.41 kg/t	0.40 kg/t	0.38 kg/t

Table 32: Longitudinal Longhole Powder Factor

Item	Longitudinal 40 m High 8 m Thick	Longitudinal 20 m High 8 m Thick	Longitudinal 40 m High 3 m Thick	Longitudinal 20 m High 3 m Thick
Hole Diameter	76 mm	76 mm	76 mm	76 mm
Total Drilling	2 867 m	1 313 m	1 670 m	725 m
Loaded Length	1 724 m	790 m	1 005 m	436 m
Total Emulsion	9 448 kg	4 327 kg	5 504 kg	2 388 kg
Slope Tonnes	26 600 t	12 400 t	11 400 t	5 100 t
Powder Factor	0.36 kg/t	0.35 kg/t	0.48 kg/t	0.46 kg/t

Figure 9: Production Design Extra Detail

Summary of the maximum charges from the designs the following can be said:

1. Various development end designs were provided. The design with the highest number of blastholes to be drilled is considered as worst-case scenario and used as basis for the evaluation - a 6 m x 6 m design with 69 holes to be drilled. The design layout suggests that a maximum of 14 production blastholes may be initiated simultaneously. This is based on expected timing to be done and the outer ring of the production holes timed with the same timing. Each production blasthole will be charged with 7.5 kg of emulsion explosives. Thus yielding a maximum charge per delay of 105 kg.
2. Various production blasting designs were presented. Again the worst-case scenario is selected. In this case a Longitudinal Long hole 40m High and 3m thick with blasthole lengths of 27 m. The production blasting consists of 76 mm diameter blastholes drilled in a ring design. It is expected that the ring could consist of up to 9 blastholes and initiated with delays of between 25 ms and 35 ms between blastholes. Using averages the maximum charge in a

blasthole could be 139 kg. normally multiple rings are drilled and blasted. Each of the rings are then also timed to be initiated independently. It is expected that the maximum charge per delay is then the 139 kg.

3. Based on the maximum charge per delay the ring blasting will yield the highest charge mass per delay. The 139 kg will be applied in evaluation.

14.1 Ground Vibration

When predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. The site constants are specific to a site where blasting is to be done. In the absence of measured values an acceptable standard set of constants is applied.

Equation 1:

$$PPV = a \left(\frac{D}{\sqrt{E}} \right)^{-b} / 2$$

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

Applicable and accepted factors a&b for new operations is as follows:

Factors:

a = 1143

b = -1.65

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

In reviewing the type of structures that are found within the possible influence zone of the proposed mining area and the limitations that may be applicable, different limiting levels of ground vibration will be required. This is due to the typical structures and installations observed surrounding the site and location of the project area. Structure types and sensitivity of the area recommends that a limit of 6 mm/s is considered.

Based on the designs presented on expected drilling and charging design, the following Table 4 shows expected ground vibration levels (PPV) for various distances calculated for the maximum charge mass.

Table 4: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 139 kg Charge
1	100.0	16.8
2	200.0	5.3
3	300.0	2.7
4	400.0	1.7
5	500.0	1.2
6	600.0	0.9
7	700.0	0.7
8	800.0	0.5
9	900.0	0.4
10	1000.0	0.4
11	1100.0	0.3
12	1200.0	0.3
13	1300.0	0.2
14	1400.0	0.2
15	1500.0	0.2
16	1600.0	0.2
17	1700.0	0.2
18	1800.0	0.1
19	1900.0	0.1
20	2000.0	0.1

Mustard Highlighted: Target depth of Ore.

15 Operational Phase: Impact Assessment

Various installations / structures and sensitive areas were observed. These are listed in Table 3. This section concentrates on the outcome of calculated ground vibration levels from underground operations and the possible effects of ground vibration. In evaluation, the charge mass scenarios selected as indicated in section 13.1 is considered with regards to ground vibration and air blast.

The following aspects with comments are addressed for each of the evaluations done:

- Ground Vibration Modelling Results
- Ground Vibration and human perception
- Ground Vibration Impact on sensitive areas.

15.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level calculated and discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns and human perception. Tables are provided for each of the different charge models done with regards to:

- “Tag” No. is the number corresponding to the POI figures.
- “Description” indicates the type of the structure.
- “Distance” is the distance between the structure and edge of the box-cut area.
- “Specific Limit” is the maximum limit for ground vibration at the specific structure or installation.
- “Predicted PPV (mm/s)” is the calculated ground vibration at the structure.
- The “Structure Response @ 10Hz and Human Tolerance @ 30Hz” indicates the possible concern and if there is any concern for structural damage or potential negative human perception respectively. Indicators used are “perceptible”, “unpleasant”, “intolerable” which stems from the human perception information given and indicators such as “high” or “low” are given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have negligible possibility of influence.

Data is provided as follows: Vibration calculated in table with predicted ground vibration values and evaluation for each POI. Additional colour codes used in the tables are as follows:

Structure Evaluations:
Vibration levels higher than proposed limit applicable to Structures / Installations is coloured “Red”
People’s Perception Evaluation:
Vibration levels indicated as Intolerable on human perception scale is coloured “Red”
Vibration levels indicated as Unpleasant on human perception scale is coloured “Mustard”
Vibration levels indicated as Perceptible on human perception scale is coloured “Light Green”
POI’s that are found inside the box-cut area is coloured “Olive Green”

Table 5: Ground vibration evaluation for charge evaluated

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
POI01	The Arch - View Point	6	1200	139	0.3	Acceptable	N/A
POI02	Makgabeng Plateau	6	1200	139	0.3	Acceptable	N/A
POI03	House	6	1200	139	0.3	Acceptable	Too Low
POI04	House	6	1200	139	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
POI05	House	6	1200	139	0.3	Acceptable	Too Low
POI06	House	6	1200	139	0.3	Acceptable	Too Low
POI07	House	6	1200	139	0.3	Acceptable	Too Low

15.2 Summary of ground vibration levels

The underground operations were evaluated for expected levels of ground vibration from future blasting operations. The sites and installations / houses / buildings are located on surface at minimum 1200 m above the underground operations.

The calculated levels are less than 0.5 mm/s at surface. Levels are such that it is less than levels that is normally perceptible by humans. It is well expected that at a level of 1200 m below surface no impact will be expected.

15.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 10 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 10 that no perception from ground vibration generated is expected on surface at levels of 0.3 mm/s.

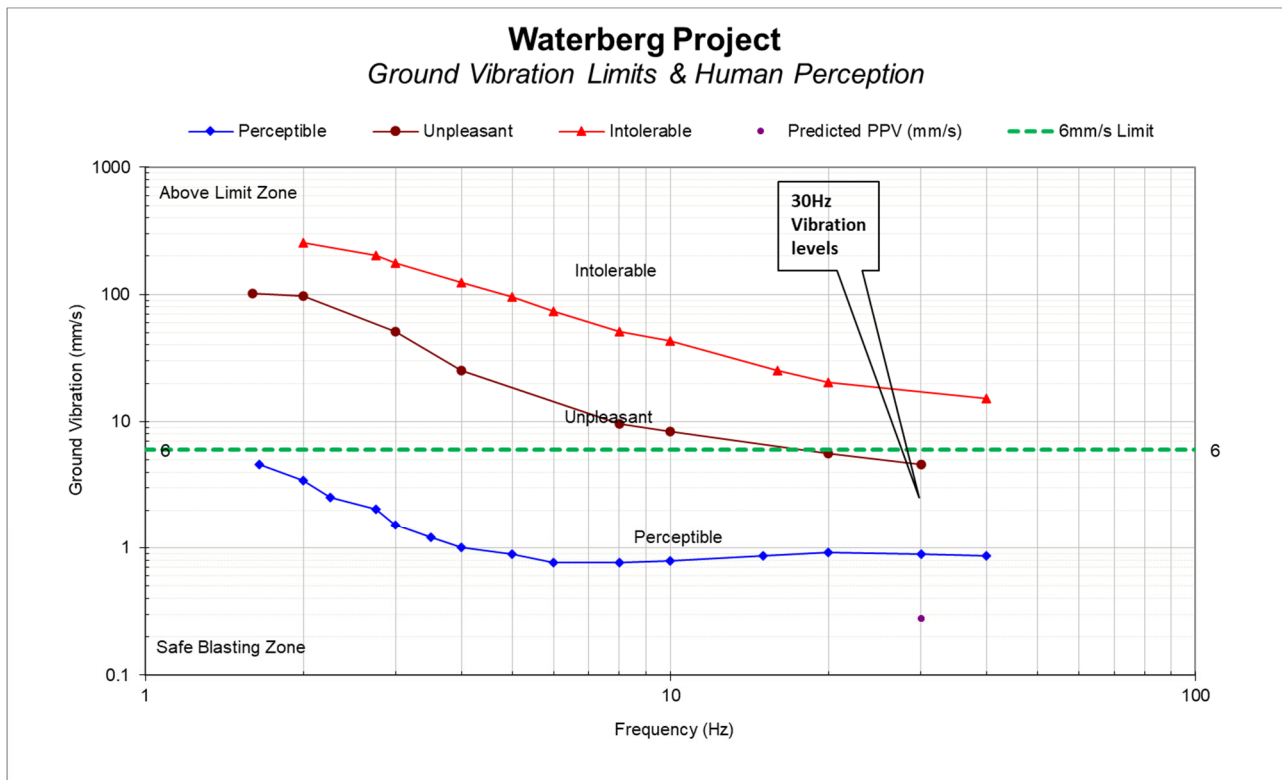


Figure 10: The effect of ground vibration with human perception and vibration limits

15.4 Impact on Sensitive areas

The sensitive nature area on surface on the farms Bonne Esperance 356 LR and Too Late 359 LR was considered. The expected levels of ground vibration at 0.3 mm/s is certain not to have any negative effect on these areas. The levels are significantly less than any form where influence can be expected.

15.5 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. The matrix below in Table 6 was used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 7 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

Assessment Methodology

$$\text{SIGNIFICANCE} = (\text{MAGNITUDE} + \text{DURATION} + \text{SCALE}) \times \text{PROBABILITY}$$

The maximum potential value for significance of an impact is 100 points. Environmental impacts can therefore be rated as high, medium or low significance on the following basis:

- High environmental significance 60 – 100 points
- Medium environmental significance 30 – 59 points
- Low environmental significance 0 – 29 points

Table 6: Scale used to determine the overall ranking

Magnitude (M)	Duration (D)
10 – Very high (or unknown)	5 – Permanent
8 – High	4 – Long-term (ceases at the end of operation)
6 – Moderate	3 – Medium-term (5-15 years)
4 – Low	2 – Short-term (0-5 years)
2 – Minor	1 – Immediate
Scale (S)	Probability (P)
5 – International	5 – Definite (or unknown)
4 – National	4 – High probability
3 – Regional	3 – Medium probability
2 – Local	2 – Low probability
1 – Site	1 – Improbable
0 – None	0 – None

The quantification of impacts is calculated for each **phase** of the operation i.e. Construction, Operation, Decommissioning, Post-closure.

15.5.1 Assessment

Table 7: Risk Assessment Outcome

No.	Receptor / Resource	Process/Activity	Environmental Impact	Impact Effect	Magnitude (M)	Duration (D)	Scale (S)	Probability (P)	Significance		Mitigation and Management Measures	Impact	
									Rating	Value		Monitoring	Time Frame for Monitoring
1	Community Houses	Blasting	Ground Vibration	Negative	-2	-3	-1	-1	Low	6	N/A	None	N/A
2	The Arch - View Point	Blasting	Air blast	Negative	-2	-3	-1	-1	Low	6	N/A	None	N/A
3	Makgabeng Plateau	Blasting	Fly rock	Negative	-2	-3	-1	-1	Low	6	N/A	None	N/A

15.6 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms.

16 Closure Phase: Impact Assessment and Mitigation Measures

During the closure phase no mining, drilling and blasting operations are expected. It is uncertain if any blasting will be done for demolition. If any demolition blasting will be required it will be reviewed as civil blasting and addressed accordingly.

17 Monitoring

No specific monitoring is recommended.

18 Recommendations

The following recommendations are proposed.

18.1 Blast Designs

Blast designs can be reviewed at time when this area is mined and expected levels confirmed.

18.2 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 8.

Table 8: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A
Water Wells	50	N/A
Telecoms Tower	50	134

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
General Houses of proper construction	USBM Criteria or 25 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Houses of lesser proper construction	12.5	
Rural building – Mud houses	6	

19 Knowledge Gaps

The data provided from client and information gathered was sufficient to conduct this study. Surface surroundings change continuously and this should be taken into account prior to initial blasting operations considered. This report may need to be reviewed and updated if necessary. This report is based on data provided and internationally accepted methods and methodology used for calculations and predictions.

20 Conclusion

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform a review of possible impacts from underground blasting operations on the farms Bonne Esperance 356 LR and Too Late 359 LR with regards to ground vibration.

The evaluation of ground vibration expected from underground blasting operations indicated that levels expected are very low and insignificant. The distance between blasting operations and surface area are in the order of 1200 m. This distance and the low quantities of charge are the main contributors to the insignificant levels of ground vibration. No impact on surface is expected.

Due to the low levels expected there is no specific mitigations required.

This concludes this investigation for the possible impact of underground blasting operations on the farms Bonne Esperance 356 LR and Too Late 359 LR for the proposed Waterberg Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

21 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.

From July 1992 to December 1995, Mr Zeeman worked at AECL Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical

Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.

From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.

Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are Pre-blast monitoring, Insitu monitoring, Post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

1985 - 1987 Diploma: Explosives Technology, Technikon Pretoria

1990 - 1992 BA Degree, University of Pretoria

1994 National Higher Diploma: Explosives Technology, Technikon Pretoria

1997 Project Management Certificate: Damelin College

2000 Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

BM&C have installed a world class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects listed above are only part of the capability and professional work that is done by BM&C.

22 References

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